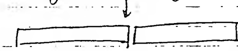
Fusion Splicing 1-5-2000

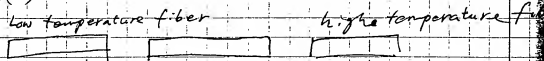
ideas (1) Directly Splicing



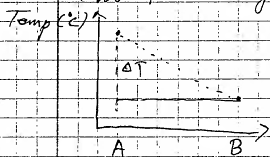
change : Splicing time
Splicing currents
Arc Position : The higher the melting point, the closer the Arc. Try to make the energy distribution assymetry, higher at closer end lower at far away end !!!

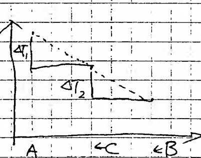
idea position : The arc position is located in where that the temperature in both ends of fibers is nearly to melting points of the fiber. (at least the soften tempera

idea (2) Immediate



two fiber system

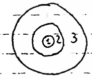




$\Delta T_1 \sim \Delta T_2 \ll \Delta T$

Order PF1 (ThorLabs)
Ultra-high NA Silica fibers
Coupler Fiber 3M

idea (3) double cladding layer



assume: $D_1 = 6.6\ \mu m$
$D_2 = 30\ \mu m$
$D_3 = 125\ \mu m$

$r_1 = 3.3\ \mu m$
$r_2 = 15\ \mu m$
$r_3 = 62.5\ \mu m$

$$\frac{S_1}{S_3} = \left(\frac{r_1}{r_3}\right)^2 = (0.0528)^2 = 0.00278$$

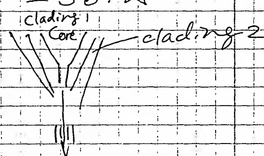
$$\ll 1\%$$

$$\frac{S_2}{S_3} = \left(\frac{r_2}{r_3}\right)^2 = (0.24)^2 = 5.76\%$$

if

$$\frac{S_2}{S_3} = 0.20 \qquad \frac{r_2}{r_3} = 0.45$$

$$r_2 = 0.45 \times 125 = 56.25$$



procedure to produce the fiber needed to be developped !!!

S_2/S_3 : 0.40 0.50 $\boxed{0.410}$

r_2 : 70.05 nm 88 nm $\Rightarrow$ 0.80

Fusion Splice test on MF Jan 9, 2001

SM+SM P01

Test time 正 正 正 正 正

Lose 0.02 dB 正 一

Lose 0.03 dB 正 下

Lose 0.04 dB 丅

lose 0.01 dB 正 0
lose 0.09 dB* 一
lose 0.05 dB 正
lose 0.11 dB 一 **
Cleved Bad 下 Dure to the Diamond clever has not move all the way cross.

* lose become 0.04 dB ~~than~~ after refuse

Cut & Refuse 下

Failure 下

** Left "recut and reuse"

right "new"
→ Refuse 0.33 dB

After electrode clean Program run, The lose estim is much lower, around 0.01~0.02 dB. Even one sample that recut & re-splice.

Manual Mode Splicing Jan 10, 2001

SM + SM P01

Totate test time 1F

lose 0.01dB

lose 0.02dB —

Lose 0.03dB F

Lose 0.04dB

Lose 0.05dB

lose 0.06dB

lose 0.08dB —

1 Change Parame rs (Prefuse curr)

	P01	P11	changed
Prefuse time	0.2S	0.2S	
Prefuse Curr	10.0mA	08.0mA	✓
Gap	50.0μ	50.0μ	
overlap	10.0μm	10.0μm	
fusion time 1	0.3 S	0.3 S	
fusion Curr 1	10.5 mA	10.5 mA	
time 2	2.0 S	2.0S	
Curr 2	16.3 mA	16.3 mA	
time3	2.0 S	2.0 S	
Curr 3	12.5 mA	12.5 mA	
left MFD	9.8 μm	9.8 μm	
Right MFD	9.8 μm	9.8 μm	
Set Center	+255	+255	
AOA Curr	0 mA	0 mA	
Early prefus	No	NO	
Align Accura	0.15μm	0.15μm	
loss shift	0 dB	0 dB	
Auto Arc Center	NO	NO	

~~Re-Edit~~

P12 Change Parameter (fusion curr 1)

	P12
prefuse	0.2S
Prefuse curr	8.0 mA
Gap	50 μm
overlap	10 μm
fusion time 1	0.3 S
fusion ~~curr~~ 1	8. mA
time 2	2.0 S
curr 2	16.3 S
time 3	2.0 S
Curr 3	~~16.3 S~~ 12.5 S
Left MFD	9.8 μm
Right MFD	9.8 μm
S.Center	+255
AOA Curr	0 mA
Early Prefus	No

P05 eccentric s i t sm

Total test time F —

lose 0.01 dB T
lose 0.02 dB T
lose 0.03 dB
lose 0.04 dB
lose 0.05 dB T

P 11 first programed

total test time F
lose 0.01 dB T
lose 0.08 dB —*

P12 changed (fusion curr 1)

~~total test time~~ F —
lose 0.05 dB T
lose 0.04 dB T
lose 0.06 dB —
lose 0.01 dB —
* 0.04 dB refuse

P13 Manual Mode

Prefuse Curr 3.0 mA ✓
Prefuse time 0.3 s

Edit
Prefuse Curr 6. mA temp. ~~too~~ high
Prefuse time 0.3 s X Matchstick

Edit
Prefuse Curr 4.5 mA X Matchstick
Prefuse time 0.3 S

Edit
Prefuse Curr 3.75 mA (3.8 mA) X
Prefuse time 0.3 S Matchstick

Edit
Prefuse Curr 3.4 mA ✓ No melting
Prefuse time 0.3 S

Edit
Prefuse Cur 3.6 mA Just a little
Prefuse time 0.3 S too high

1) fiber cannot be cut by clever
Mechanical property is poor

2) Prefuse Current 3.6 mA
Prefuse time 0.3 S

Current is very low

P14

Prefuse time	0.2 s
Prefuse Curr	3.4 mA
Gap	50 µm
overlap	10 µA
fusion time 1	0.3 s
fusion Curren 1	3.65 mA
fusion time 2	2.0 s
fusion Curr 2	3.65 mA
fusion time 3	2.0 s
fusion Curr 3	3.4 mA
Left MFD	9.8 µm
right MFD	9.8 µm
Set center	+255
ACA Curr	0 mA
Early prefuse	NO
Align Accura	0.15 µm
loss shift	0 dB
Auto Arc Center	NO

too high for Erbium Glass, too low for SMF28
The fiber of Erbium Glass is not unifor
in ~~Eadi~~ Diameter

Fibercore glass

DF1500F-980 Erbium Doped Fibre
SD 278A-01A
"C-band" 1530-1560 nm
DF1500L special Erbium-doped Fibre
"L-Band" SD 188B-00E
Concentrate twice as high as DF-1500F
~1600 nm

DF1500L

	DF1500L	DF1500F-0980	
Fiber Diameter	125 μm	125	μm
NA	0.21	0.24	
Cut-off	955 nm	970	nm
Attenuation	25 dB/Km 1200 nm	6.8 dB/KM	
Absorption	11.5 dB/m @ 979 nm	4.8 dB/m	
	14.6 dB/m @ 1531 nm	6.6 dB/m	

Composition Core Silica/germania
Inner cladding Silica
Coating Dual Coat UV Cure Acrylate
240 μ Diameter
Mechanical
proof test @ 1% Strain

Same as left

Program 01.

manual DF1500L & ~~A~~ SMF-28 fusion splicing

0.09dB 𝍩
0.06dB
0.02dB

Auto mode
0.07
0.01
0.02

SD278A-01A & SMF-28

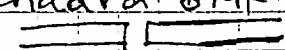
0.01 dB
0.03 dB
0.02 dB

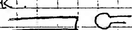
Program 15 a   Jan 16 202

	15 a	15 b	15 c	
Prefuse time	0.2 S	0.2 S	0.2 S	0.2S
Prefuse Curr	3.3 mA	3.3mA	3.0 mA	2.8mA
GAP	50 μm	50 μm	50 μm	50 μm
overlap	10 μm	10 μm	10 μm	10 μm
Fusion time 1	0.3 S	0.3 S	0.3 S	0.3 S
Fusion Curr	3.3 mA	3.3 mA	3.0 mA	2.8 mA
Fusion time 2	1.0 S	0.3 S	0.3 S	0.3 S
Fusion curr	3.3 mA	3.3 mA	3.0 mA	2.8 mA
Fusion time 3	1.0 S	0.3 S	0.3 S	0.3 S
Fusion Curr 3	3.3 mA	3.3 mA	3.0 mA	2.8 mA
left MFD	4.8 μm	4.8 μm	←	←
Right MFD	4.8 μm	4.8 μm	←	←
Set Center	+255	+255	←	←
AOA Current	0 mA	0 mA	←	←
Early Prefuse	No	No	←	←
Align Accura	0.15 μm	0.15 μm	←	←
Loss shift	0 dB	0 dB	←	←
Auto Arc Center	no	NO	←	←
		← Same as left		

Result

	15 b	15 c	
(1) can not fusion splice two standard SMF-28 fiber	Same as 15a	Not good ← Same	Can[illegible] stick togeth[illegible]
(2) Prefusion cannot clean up SMF-28 Fiber but do melt the phosphate fiber a little. fusion stage make to phosphate fiber melting and becoming a match-stick.	Same as 15 a	Not good ← Same	Since phosph[illegible] doesn't melt





15 d	15 e	15 f	15 g	15 h
	0.2 S	0.2 S	0.1 S	0.1 S
2.8 mA	2.9 mA	2.9 mA	3.3 mA	3.2 mA
	50 μm	50 μm	50 μm	50 μm
	10 μm	10 μm	10 μm	10 μm
0.3 S	0.3 S	0.6 S	0.1 S	0.1 S
2.8 mA	3.0 mA	3.9 mA	3.3 mA	3.2 mA
1.3 S	0.3 S	1.3 S	1.3 S	1.3 S
2.8 mA	2.9 mA	2.9 mA	2.8 mA	2.8 mA
1.3 S	1.3 S	1.3 S	1.3 S	1.3 S
2.8 mA	2.9 mA	2.9 mA	2.8 mA	2.8 mA
←	←	←		
←	←	←		
←	←	←		
←	←	←		
←	←	←		
←	←	←		
←	←	←		
←	←	←		
NP fiber Did NOT melt !!!	NP fiber Did melt	melt !!!	Prefuse work fuse ⇒ melt	Prefuse wo fuse mel
Discharged!				

NP Photonics, Inc.
Invention Disclosure Form

I. Description

Please provide a title for your invention and a brief description. Inventions include new processes, products, apparatus, compositions of matter, living organisms – OR improvements to (or new uses for) things that already exist. Use additional sheets and attach descriptive materials to expand answers to questions. (Sketches, drawings, photos, reports and manuscripts will be helpful.)

A. Invention Title: Method of Fusion Splicing Silica Fiber with Multi-component Glass Fiber

B. Description:

This invention discloses a method of fusion splicing silica fiber with multi-component glass fibers. Here the multi-component glass referees to glass containing glass network former, network modifier and/or glass network intermediator, such as phosphate glass, silicate glass, borate glass, germante glass and tellurite glass. Figure 1 (a) and (b) illustrate the design of the multi-component glass fiber for fusion splicing with silica fiber.

In Figure 1 (a), the single mode core is the doped glass, for example, erbium and ytterbium doped phosphate glass, the first cladding layer is undoped or specially doped glass, for example, undoped phosphate glass or specially doped phosphate glass, the second cladding layer is a silicate glass which will play a key rule in fusion splicing. The diameters of the single mode core, the first cladding layer and the second cladding layer could be around 4 to 10 μm, 15 to 50 μm, and 125μm, respectively. The silicate glass for the second cladding glass would be selected that the softening temperature of the glass is close to the core glass and the first cladding glass, so these three glasses can be drawn into fiber without problem. The cross section of the second cladding layer is significantly larger than the core and the first cladding layer. The second cladding layer plays a key rule in fusion splicing. Typically the decreasing rate of viscosity of silicate glasses is much lower than that of phosphate glasses when the temperature increases, so the working temperature range for silicate glasses is broader than that of phosphate glasses. In addition, the bond strength between the silicate glass fiber and silica fiber should be stronger than that between the phosphate glass fiber and silica fiber due to the similar glass network structure between the silicate glass and silica.

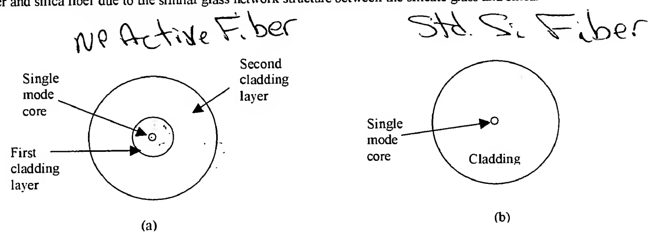


Figure 1. Design of single mode fiber for fusion splicing with silica fiber

It should be pointed out that in some cases, the first cladding layer might not be necessary as illustrated in Figure 1 (b). In Figure 1 (b), the single mode core is the doped glass, for example, erbium and ytterbium doped phosphate glass, and the cladding is a silicate glass.

C. What are the immediate and/or future applications of the invention?

Fiber amplifiers. fiber lasers. fiber optical communications

D. Why is the invention better – more advantageous – than present technology? What are its novel and unusual features? What problems does it solve?

There is no existing technology to fusion splicing silica fiber and phosphate glass fiber.

E. Is work on the invention continuing? Are there limitations to be overcome or other tasks to be done prior to practical application? Are there any test data?

Yes. No test data yet.

F. Have products, apparatus or compositions, etc. actually been made and tested?

No.

II.Publications, Public Use and Sale

Note: valid patent depends on accurate answers to the following items.

A. Has invention been disclosed in an abstract, paper, talk, news story or a thesis?

Type of disclosure: No. (Please enclose a copy) Disclosure Date:

B. Is a publication or other disclosure planned in the next six months?

Type of disclosure: No. (Enclose drafts, abstracts, preprints) Disclosure Date:

II.(Publications, Public Use and Sale – Continued)

C. Has there been any public use or sale of products embodying the invention?

No.

Describe, giving dates:

D. Are you aware of related developments by others? If "yes," please give citations. Copies of any relevant patents or publications would be appreciated.

No.

III.Sponsorship

If the research that led to the invention was sponsored, please fill in the details and attach a copy of the contract or agreement if possible.

A. Government agency: No. Contract/Grant no.

B. Name of industry, university, foundation or other sponsor: No.

C. Has the invention been disclosed to industry representatives? If "yes." please provide details. including the names of companies and their representatives.
No.

IV.For Our Records

A. Names and titles of inventors (please print; sign where indicated)

1. Shibin Jiang Signature Date 01/31/01

2. Jiafu Wang Signature Date 01/31/01

B. Contact for more data Tel.

C. Mailing address for inventor(s)
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(520) 799-7402, (520) 799-7403 fax

D. Name and title of institutional representative (please sign where indicated)

Signature Date

Department Tel.

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